RECLAMATION

era

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RECLAMATION era

Kathleen Wood Loveless, Editor

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Bureau of Reclamation,
Gilbert G. Stamm, Commissioner

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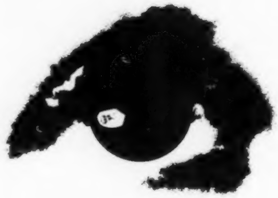
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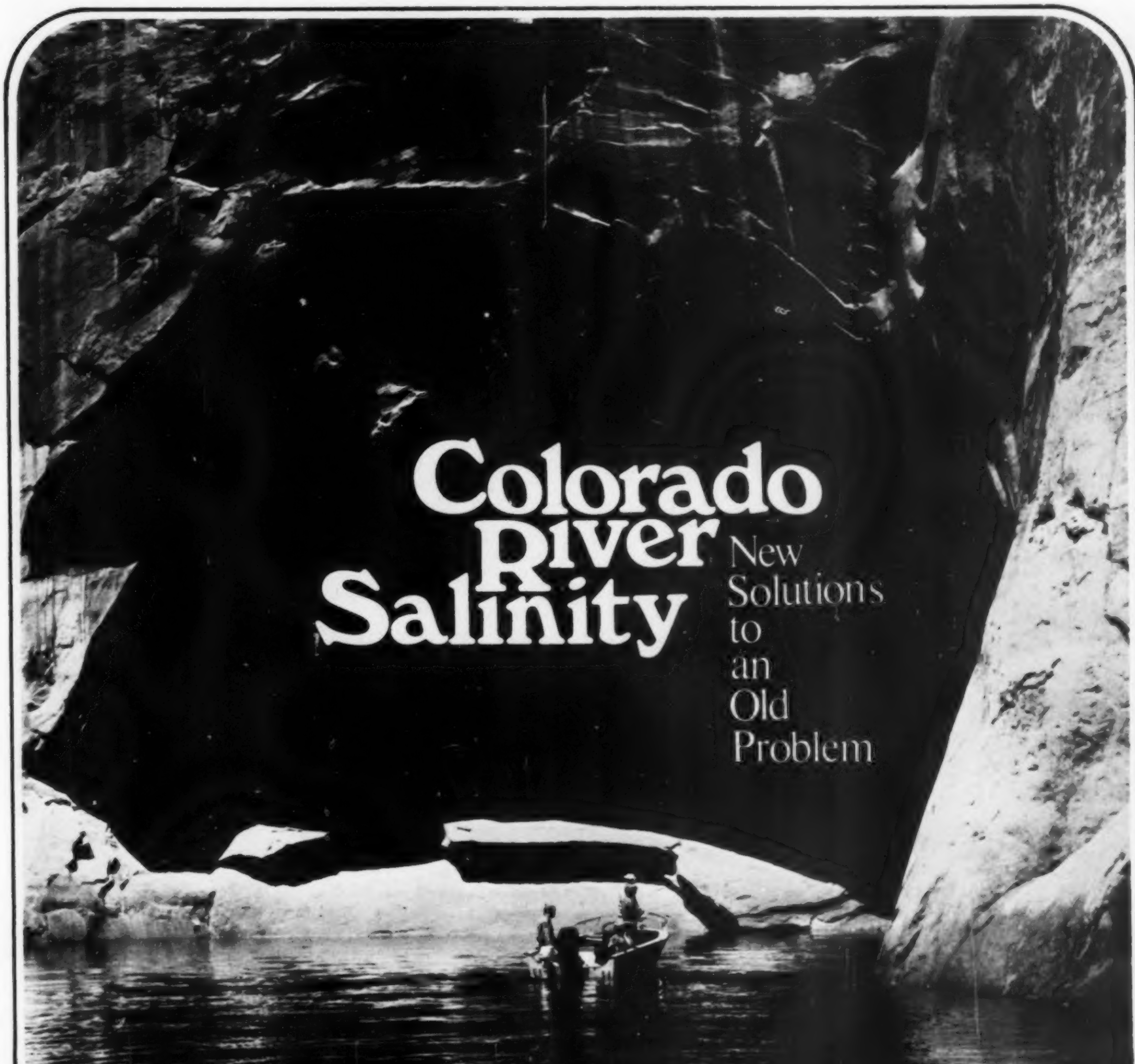
The Bureau of Reclamation, which has built mammoth storage projects to harness the Colorado River and stabilize its unpredictable water supply, is now gearing up for a full-scale attack on another of the river's oldest problems—water quality.

On June 24, former President Nixon signed a bill from Congress authorizing a $280.6 million program aimed at controlling the salinity of the river.

The bill will benefit water users in both the United States and Mexico. It fulfills a pledge Mr. Nixon made 2 years ago to the President of Mexico to find a "permanent" solution to an international problem which has affected relations between the two countries for over a decade. It also authorizes $125 million for salinity control projects upstream from Imperial Dam to improve water quality in the Lower Basin.

The Bureau of Reclamation will be the primary agency constructing the physical facilities used to carry out the salinity program. The Bureau will receive assistance and cooperation from other agencies including: Office of Water Research and Technology, Department of Agriculture, Corps of Engineers, Inter-



national Boundary and Water Commission and local irrigation districts.

In addition to being an international problem, the growing salinity level of the river adversely affects some 10 million people in the United States and 1 million acres of fertile, irrigated U.S. farmland in the lower stretches of the river where the salinity is greatest.

The effect is also costly. Experts estimate that the loss to the regional economy along the 1,400-mile river due to the poor quality of water was about $53 million in 1973. By the year 2000, losses could reach about $124 million per year if water resource development continues and no salinity reduction measures are instituted.

The losses are borne by virtually everyone from farmer to urban homeowner, and from Government to industry.

A high concentration of dissolved solids in irrigation water decreases crop yields, forces changes in crop patterns, and increases management cost for the individual farmer.

Likewise, the average homeowner suffers an economic loss from high salinity water which accelerates pipe corrosion and appliance wear. The hard water also requires the use of more soap and detergent to clean clothes and dishes.

Cities must bear increased water treatment costs, including replacement of corroded water delivery systems. But municipalities are not alone, industries also suffer equipment damage caused by corrosion.

The increase of salinity in the Colorado River is not new or unique. Changes in water quality along the river were noted as early as 1903, and the seven States in the Colorado River Basin have wrestled with the problem for years. Mexico bears the heaviest burden of the Colorado's salinity and the country demanded that the United States take action to clean up the river at the international border.

But the concentration of dissolved minerals in the Colorado is increasing as the States of the Upper and Lower Basins claim more of their share of the river for consumptive use. And man's use of the water is part of the problem.

As the Colorado winds its way from the headwaters

Former President Nixon signs the bill authorizing a $230.6 million program aimed at controlling Colorado River salinity. Attending are (l to r) Rep. Peter Frelinghuysen (R-N.J.), Rep. Sam Steiger (R-Ariz.), Sen. Paul Fannin (R-Ariz.), Dr. Jose Juan de Olliqui, Ambassador Extraordinary and Plenipotentiary—Mexico, Jack B. Kubish, newly appointed Ambassador to Greece and former Assistant Secretary of State, former President Nixon, Rep. Craig Hosmer (R-Calif.), Sen. Mike Mansfield (D-Mont.), Rep. Harold Johnson (D-Calif.), Sen. Clifford Hansen (R-Wyo.), John C. Whitaker, Under Secretary of the Interior.

Wellton-Mohawk Main Conveyance Channel—Colorado River, International Salinity Control project, Ariz.

in the Rocky Mountains to the Gulf of California, it picks up drainage from parts of Colorado, Utah, Wyoming, New Mexico, Arizona, Nevada, California, and Mexico.

The river water is used and reused many times through its journey, reducing the water volume and increasing the salinity. Along the way, the river picks up about 10 million tons of salts and other minerals annually—about one-half from natural sources and the other half from man's use. Irrigation has the effect of concentrating salts in the remaining water, in addition to leaching minerals from the soil which enter the river in return flows. Use of water for municipal and industrial purposes also increases salinity, as does reservoir evaporation and the diversion of low-salinity water from the natural basin of the river.

Natural sources of salinity include salt domes, springs, abandoned wells, and geysers.

Salinity levels in the Colorado River now range from less than 50 parts per million at the headwaters to average concentrations of about 850 parts per million at Imperial Dam, near Yuma, Ariz. If no salinity control measures are undertaken, annual concentrations of total dissolved solids (t.d.s.) at Imperial Dam by the year 2000 could range as high as 1,300 parts per million, with seasonal peaks being higher.

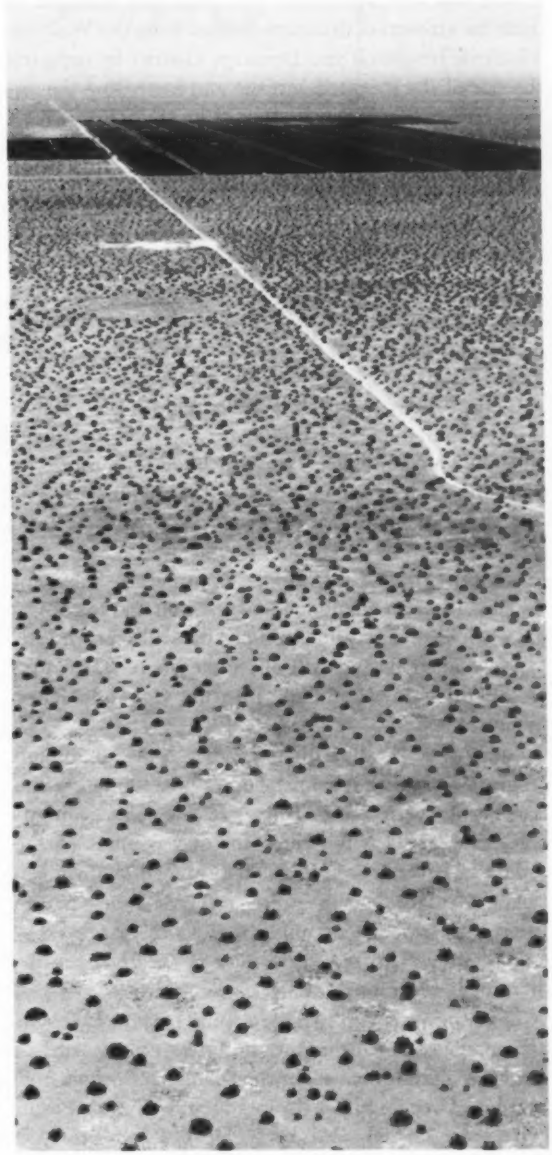
The salinity problem has been the object of a number of past studies by universities and State and Federal agencies. In 1972, a conference was convened by the Environmental Protection Agency to discuss the pollution of the interstate waters of the Colorado River.

Representatives of the seven Colorado River Basin States and interested Federal agencies agreed on the objective of maintaining salinity concentrations at or below levels presently found in the lower mainstem of the river while the Upper Basin continues to develop its compact-apportioned waters. The urgency of a basinwide salinity control program is also underscored by the anticipated need for water to develop Western States' energy resources. Couple this with the fact that water demands along the river are already approaching dependable supply and the urgency is compounded.

But it was a formal protest by our southern neighbor, Mexico, which started the chain of negotiations and agreements leading finally to passage of legislation implementing a permanent solution to the problem.

In 1961, 11 years after the United States first began delivery of Colorado River water to Mexico under the 1944 treaty, two events occurred to make water quality a serious issue between the two countries. Highly saline drainage waters from the Wellton-Mohawk Irrigation

The desert of the Yuma Mesa is a striking contrast to the agricultural development near the Mexican Border.



and Drainage District were pumped from an aquifer underlying the district to maintain ground water levels below the crop root zone. These waters became part of the delivery to Mexico. In addition, excess flows which Mexico had received prior to 1961 were cut off as U.S. users upstream completed storage projects. These excess flows had diluted the more saline drainage waters that were being delivered as a part of Mexico's treaty entitlement to waters of the Colorado River.

The effect of these developments was to increase the salinity of water flowing into Mexico at the United States-Mexico border from an annual average of about 800 parts per million (t.d.s.) to nearly 1,500 parts per million.

Mexico filed a formal protest with the United States, beginning a series of negotiations, agreements, and stopgap measures to reduce the salinity of the river at the border.

In June 1972, former President Nixon met with President Echeverria of Mexico in Washington, D.C. The two leaders issued a joint communique pledging to seek a definitive, equitable, and just solution to the problem. Former President Nixon appointed former Attorney General Herbert Brownell, Jr., as his Special Representative to head an interagency task force to work out a solution.

On August 30, 1973, the joint recommendations of Brownell and the Secretary of Foreign Relations of Mexico, Lic. Emilio O. Rabasa, were approved by the two governments and incorporated in Minute No. 242 of the International Boundary and Water Commission.

The provisions of that agreement with Mexico formed the basis of the legislation approved by Congress to reduce the salinity of the water delivered to Mexico.

The bill, passed by Congress and signed by the President, authorizes $155.5 million for a large desalting plant complex to be constructed near Yuma, Ariz., and facilities to manage, treat, and dispose of drainage return flows from the Wellton-Mohawk Irrigation and Drainage District, a significant source of salinity in river water which enters Mexico. Other elements of the program include installing a protective pumping well field, and lining or reconstructing about 49 miles of the Coachella Canal to reduce conveyance losses.

The desalting complex near Yuma will consist of a desalting plant with a capacity of about 129 million gallons per day; a pretreatment facility for settling, softening, and filtrating the drain water; appurtenant pumps, pipelines, and power transmission facilities; an extension of the existing drainage conveyance facil-

ities to the Santa Clara Slough in Mexico; and roads and railroad lines. It is estimated that the desalting plant will recover at least 70 percent of the drainage and remove at least 90 percent of the impurities.

The bill also authorizes two programs designed to limit the amount of drainage outflow from the Wellton-Mohawk Irrigation and Drainage District by reducing the size of the irrigated acreage and increasing the on-farm irrigation efficiency.

In addition, the bill authorizes $125.1 million for salinity control measures upstream from Imperial Dam. This includes the following:

Paradox Valley Unit, Colorado—A $16 million project to intercept saline ground water presently flowing into the Dolores River and to convey these flows to a solar evaporation basin. This will eliminate an estimated 180,000 tons of salt annually from the Colorado River.

Grand Valley Basin Unit, Colorado—A $59 million project to reduce salt inflow to the river by about 200,000 tons annually. This will be accomplished by the lining of irrigation ditches and more efficient irrigation practices in an irrigated area of about 76,000 acres.

Crystal Geyser Unit, Utah—A project to intercept the flow from an abandoned oil test well and to convey it to a solar evaporation pond. This will cost an estimated $500,000, and will eliminate about 3,000 tons of salt discharged annually into the Colorado River system.

Las Vegas Wash Unit, Nevada—A $49.6 million program to intercept saline ground water entering the Las Vegas Wash and to convey it to a solar evaporation pond. This will reduce the salt content of the Colorado River by about 138,000 tons annually.

The legislation further directs the Secretary of the Interior to expedite planning reports on 12 other potential projects to reduce salinity in the river and to submit his recommendations to Congress.

These projects will include a combination of irrigation management techniques and desalting systems in the Lower Gunnison, Glenwood-Dotsero Springs and McElmo Creek areas of Colorado; the Uintah Basin, Price, San Rafael, and Dirty Devil River areas of Utah; the Big Sandy River area of Wyoming; the Littlefield Springs and Colorado River Indian Reservation areas of Arizona; and the Palo Verde Irrigation District of California.

The desalting program for the Colorado River thrusts the Bureau of Reclamation into a new phase of water resource management in an area where the quality of water becomes as important as the quantity in the continuing struggle to conserve every drop.

LOCATION MAP

EXPLANATION

● Initial Projects Upstream of Imperial Dam

④ Future Projects Upstream of Imperial Dam

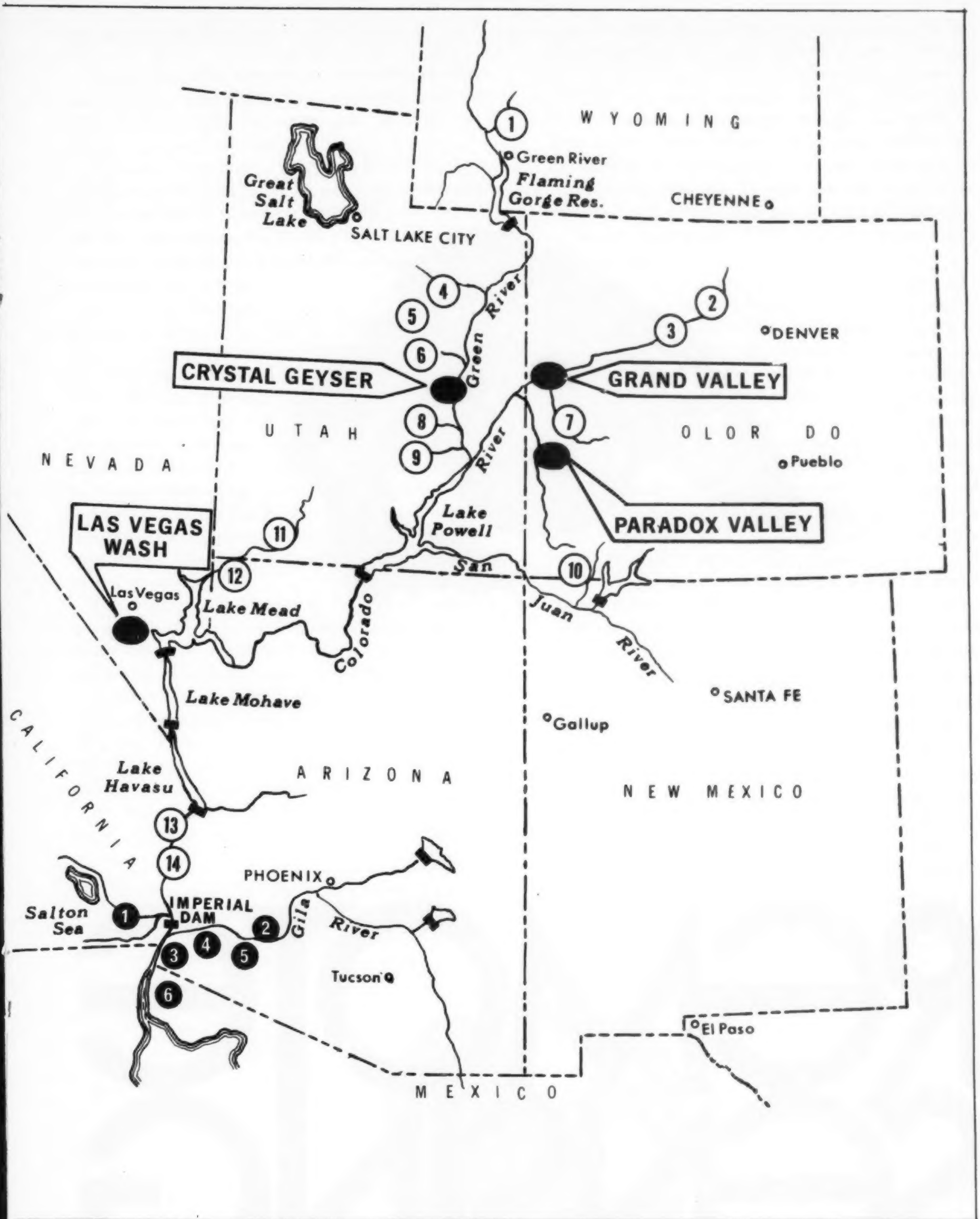
❸ Mexican Agreement Projects

Future Projects Upstream of Imperial Dam

1. Big Sandy Creek
2. Dotsero Springs
3. Glenwood Springs
4. Ashley Creek
5. Uintah Basin
6. Price River
7. Lower Gunnison
8. San Rafael River
9. Dirty Devil River
10. McElmo Creek
11. La Verkin Springs
12. Littlefield Springs
13. Colorado River Indian Reservation
14. Palo Verde Irrigation District

Mexican Agreement Projects

1. Lining of Coachella Canal
2. Painted Rock Dam
3. Yuma Mesa Wellfield
4. Desalting Plant
5. Wellton-Mohawk Division Irrigation Management
6. Extension of Wellton-Mohawk Drain


WYOMING
Green River
Flaming Gorge Res.
CHEYENNE
Great Salt Lake
SALT LAKE CITY
Green River
DENVER
CRYSTAL GEYSER
GRAND VALLEY
UTAH
OLOR DO
Pueblo
NEVADA
River
PARADOX VALLEY
LAS VEGAS WASH
Lake Powell
San Juan River
Las Vegas
Lake Mead
Colorado
Lake Mohave
SANTA FE
Gallup
CALIFORNIA
Lake Havasu
ARIZONA
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PHOENIX
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Salton Sea
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REMOTE SENSING

by Robert R. Ledzian

Today, more than ever before, Americans recognize that Earth has a limited ability to support life and that its resources—food, air, water, soil, minerals, and energy—are not boundless.

A growing population and an ever-expanding technology place huge demands on our natural resources. We are beginning to realize more and more the tremendous impact man has on the environment and we sometimes learn too late some of the unfortunate consequences of our actions.

We can no longer treat our resources strictly according to immediate economic dictates; a balance must be struck between the short-term demands of technological and industrial development and the long-term effects on the environment. We need to seek a better understanding of these limits and the effects of our activities so that we do not exceed them. To understand, we need information to predict the consequences of human interactions with the environment. The management of our Earth resources is one of the most pressing areas of public need and the effective utilization of new technologies to meet these needs is of paramount importance.

The dramatic acceleration of the rate of change in our social and physical environments dictates that new technologies be integrated rapidly into information gathering, analysis, and evaluation processes.

Within the technology of the space age lies a key to increased knowledge about the resources of the Earth. This key is remote sensing—the acquisition of data from a distant platform for detecting the nature of an object without actually touching it.

An early form, and still one of the most useful forms of remote sensing, is photography. Within the past few years the making of aerial photographs has been augmented by remote sensing, a new technique, in which sensing is done simultaneously in several bands of the electromagnetic spectrum. In its fullest form, remote sensing ranges through the spectrum from the very short wavelengths at which gamma rays are emitted to the comparatively long wavelengths at which radar operates. In this way, far more information can be secured than can be obtained from conventional photography, which is limited to the visible light portion of the spectrum.

The human eye, the primary remote sensor, sees differences in radiation being reflected from objects and relays these perceptions in the form of signals to the brain, where they are identified and classed according to memory. The eye's ability to discriminate, however, is restricted to a narrow range—the visible portion—of the electromagnetic spectrum. This spectrum consists of the X-ray, ultraviolet, visible, infrared, microwave, and radio bands. Technology has produced sophisticated sensors that can now capture and record reflected and emitted radiation in other than just the visible sector which has expanded our effective vision to include the invisible regions.

Remote sensing can be done from aircraft or spacecraft, including unmanned satellites. It employs cameras and a number of other sensing devices, and the data obtained can be processed and interpreted automatically, so that a large volume of information can be dealt with rapidly. Such photography and imagery (pictures by instruments other than photographic cameras) is comprehensive and transcends sectional, legal, and political boundaries. The importance of remote sensing is further magnified by the fact that data obtained through its application are periodic and systematic, interdisciplinary, and interprofessional.

Remote sensing by satellite is providing scientists with a unique tool for investigating the Earth and its environment. Basically, the approach involves analysis of ground-based, aerial, and satellite data by a tech-

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Mr. Ledzian is a Civil Engineer and the Earth Resources Observation Systems (EROS) Coordinator for the Bureau of Reclamation, Washington, D.C.

nique known as multistage sampling. In this technique, data acquired over small areas by ground surveys are correlated with aerial and space photographs of the same areas. Then the satellite data, which includes a much larger area and provides repetitive coverage, is used to extrapolate and update the results of the other three sources. Maximum advantage is taken of the synoptic and repetitive view of the satellite, thus minimizing the coverage and frequency of data to be obtained by conventional means.

Based on the potential of this technology and in response to the critical need for greater knowledge of the Earth and its resources, former Secretary of the Interior Stewart L. Udall established the Earth Resources Observation Systems (EROS) program in 1966. As a Departmental effort under the management of the U.S. Geological Survey, the EROS program gathers and uses data on natural and manmade features on the Earth's surface.

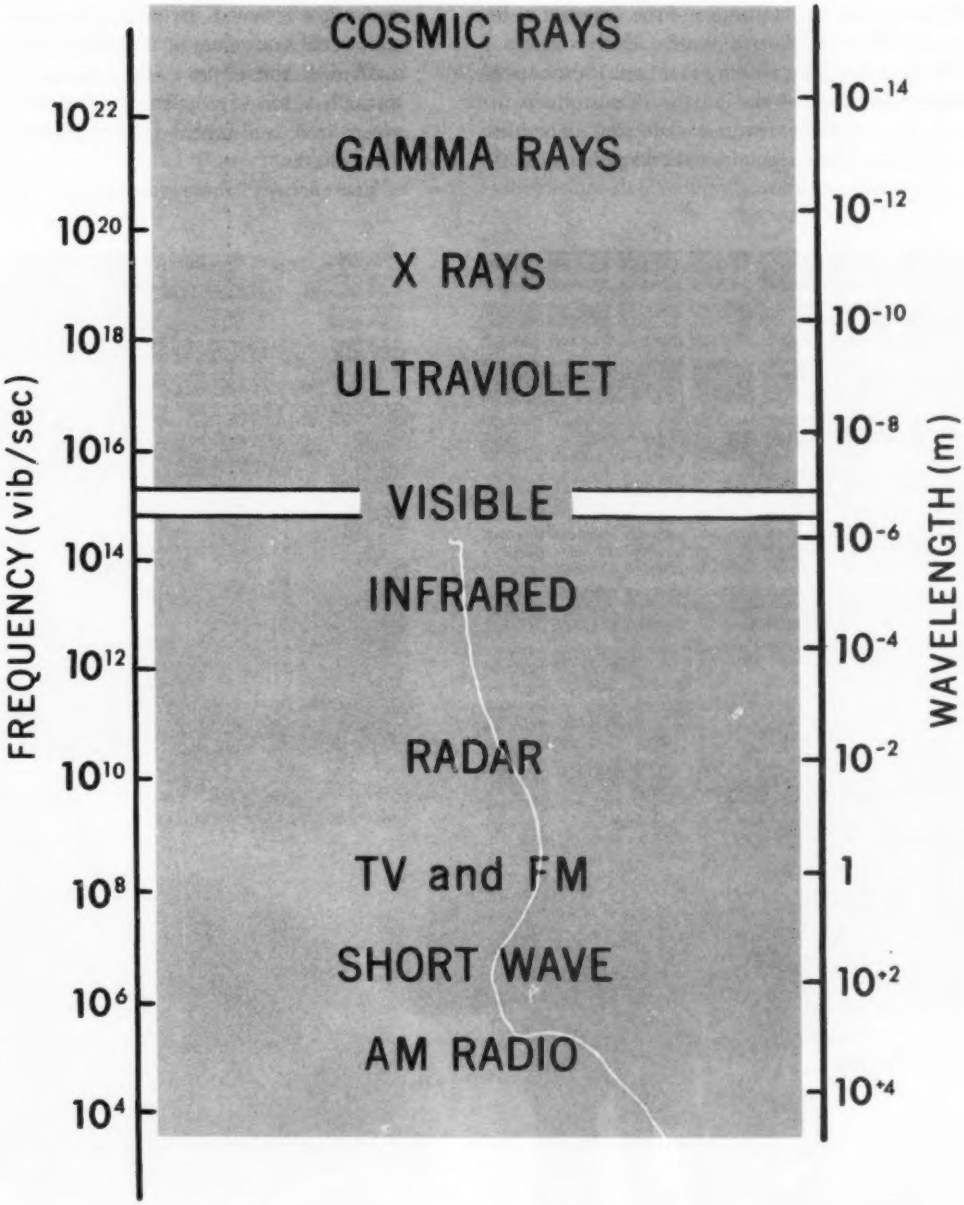
The objective of the EROS program is to avail all types of space data for effective resource utilization. It is supported by a satellite data collection system developed in collaboration with the National Aeronautics and Space Administration (NASA) and other resource agencies. The EROS program assumed a major role in the first Earth Resources Technology Satellite (ERTS–1) launched by NASA July 23, 1972. The role was to determine the potential for mapping, monitoring, and managing the Earth's resources. The satellite had an expected operational life of only 1 year but most systems are still functioning and ERTS is continuing its survey of planet Earth. A second ERTS is being readied for launching late this year or early in 1975.

ERTS is 10 feet high by 13 feet wide with its solar-power wings extended. It is in an orbit 575 miles up, circling the Earth pole-to-pole in 103 minutes. The orbit is sun-synchronous which means it crosses the same spot on Earth at the same time every 18 days. This permits scientists to get images with the same sun angle for comparison.

ERTS has orbited the Earth more than 10,000 times; taken more than 100,000 images, each covering 100-by-100 nautical miles. All of the United States has been imaged at least once and some of it 10 times. More than three-quarters of the world's land masses and coastal areas have been imaged at least once in cloud-free conditions. The satellite payload also includes a data collection system (DCS) which collects information from 200 data collection platforms (DCP) at remote sites on the ground and relays the information to ground stations for delivery to users. Over 1 million messages involving data on items such as streamflow, snow depth, and volcanic activity have

San Francisco Bay Area as seen from ERTS.

ELECTROMAGNETIC SPECTRUM



Remote sensing technology expands our ability to see into the invisible regions.

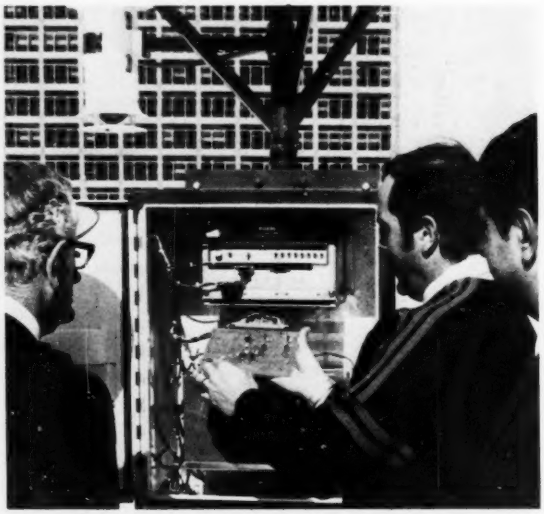
been relayed from these platforms.

Aboard ERTS, two imaging systems sense and record radiation in several visible and near-infrared bands. The first of the two imaging systems is the return beam vidicon (RBV). This system is a package of three "television cameras," each equipped with different filters that restrict passage of the reflected radiation to specific wavelength bands. Each camera is alined so that it will be viewing identical 100-nautical-mile-square portions of the Earth. The products are three images of those features reflecting only blue-green, green-red, and red-infrared energy bands in the electromagnetic spectrum.

The second system is the multispectral scanner (MSS) which operates on a different principle. Whereas the RBV takes an "instantaneous" or "still" picture, the MSS continuously records reflected radiation along the spacecraft's flight in a "moving" picture. The MSS has the advantage of producing better quality images although its products are not as geometrically reliable as those of the RBV's. The MSS uses an oscillating mirror to reflect radiation from Earth through a series of optical filters that pass only the green, red, red-infrared, and near-infrared energy wavelengths.

The energy of these wavelengths is sensed by detec-

Data Collection System in front of the E&R Center.



Scientists at the E&R Center inspect the ERTS Data Collection System circuitry.

ERTS-1 dipole antenna with protective fiberglass radome and temperature sensor.

tors that transmit this information to the Earth-based data centers. At the data centers each signal is arranged into 1 of 64 different intensity levels and each level is recorded on computer tapes that can be used to produce film or computer output products. This data is used to produce both black and white and "false" color pictures, so-called because vegetation shows up red under infrared photography. These images are available to anyone through the EROS Data Center near Sioux Falls, S. Dak. for a nominal charge.

In the multistage sampling described earlier, the spectral, temporal, and spatial characteristics of the satellite data are exploited by techniques known as multispectral analysis, change detection analysis, and pattern recognition.

Every object reflects sunlight differently in various wavelength bands of the electromagnetic spectrum. Multispectral analysis is based on this fact. For instance, muddy water reflects sunlight in the blue and green spectral regions but not in the near-infrared. Vegetation reflects sunlight strongly in the near-infrared and much less in the visible portion of the spectrum.

Even within a broad class of objects like vegetation, different kinds such as spruce, willow, and grass, or different states of the same type, such as healthy grass and moisture-deficient grass, will have distinctive multi-

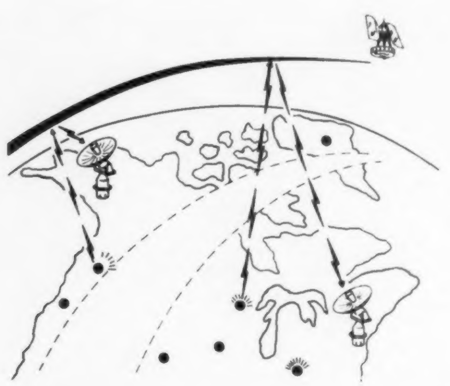
The United States as photographed by ERTS. Photo Courtesy, U.S. Geological Survey.

Olin Foehner, Division of Atmospheric Water Resources Management, receives ERTS weather information at the E&R Center.

spectral signatures. The more subtle the difference in classes, types, or states of objects, the greater the number of images in different spectral bands required to define their multispectral signatures.

Some airborne remote sensing systems image the ground in as many as 25 wavelength bands. ERTS was designed to image the Earth's surface in four wavelength bands carefully chosen to differentiate between the greatest number of objects, consistent with payload limitations and economics.

Although the multispectral information content of the data is contained in the four separate spectral bands, it is often difficult for the mind to combine these data into a multispectral signature. Two techniques are used to do this: first, development of a "false" color image by a photographic process, and



second, classification by a computer analysis of ERTS data on digital magnetic tape.

In the photographic process, a color image is produced by projecting three of the black-and-white images through appropriate filters and superimposing the resulting images. In principle, any combination of image and filter can be used to emphasize any particular feature. For analysis of vegetation the assignment of a blue color to the band four image, green to band five, and red to band six or seven stimulates color infrared film and is found most useful.

Computer processing permits more quantitative treatment and, consequently, more immediately applicable results. When multispectral signatures are identified with the nature of the objects on the ground they can be entered into the computer which, by processing the digital ERTS data and signatures together, produces a classification map.

Multispectral analysis can be applied to most of the environmental disciplines, such as geology, hydrology, and oceanography. In general, however, multispectral analysis is less useful in geology than in other disciplines. One must rely more heavily on other techniques such as associations among geologic composition and vegetation characteristics and pattern recognition. In hydrology, multispectral analysis has proved very useful in differentiating between clear and turbid water, shallow and deep water, new and old snow, and to a lesser extent, dry and melting snow.

Change detection analysis utilizes the fact that the Earth's surface has been, and continues to be, in a constant state of change. Seasons change and with them the vegetation grows, matures, and decays; snow falls, melts and disappears. Sporadic phenomena also occur: Floods occur and river courses are changed; forest fires develop, are extinguished, and with time vegetation is reestablished; earthquakes occur, volcanoes erupt, and severe storms develop, some which significantly alter the Earth's surface and coastal areas.

All of these effects are observable by ERTS (cloud cover permitting) by comparing ERTS scenes of the same area obtained at different times. When used in conjunction with multispectral analysis, the change detection technique can be a powerful supplement. For example, it highlights spectral signatures for vegetation which grows, matures, and dies at different times, such as coniferous and deciduous trees, healthy and diseased forests, and agricultural crops.

Pattern recognition analysis is based on the fact that many land features have characteristic shapes. Manmade features normally have geometric form—straight lines for highways, rectangular shapes for agricultural fields, abrupt terminations for reservoirs, circular patterns from center-pivot sprinkler irrigation systems, etc. Natural features also often have characteristic shapes which, indirectly or directly, identify the nature of the object until verification by ground truth.*

By using these analysis techniques, investigators around the world are discovering more than they expected because of this novel way of looking at the Earth. ERTS allows us to see things we have never seen before. This "eye in the sky," like a microscope, is opening a whole new world of vital information which cannot only improve the way we live, but can protect the environment we live in. It has performed so well that scientists throughout the world are using it as an operational satellite rather than as an experimental one.

*"Ground truth" is information concerning the actual state of the ground at the time of a remote sensing overflight. This information is obtained by methods other than remote sensing.

REMOTE SENSING

Reclamation's Valuable Tool For Resource Management

Remotely sensed data is recognized as a valuable tool in the investigation, planning, development, and management of Reclamation projects. The Bureau is developing the ability to use remotely sensed data in its operations. The programs that use this data are directed toward the solution of typical Bureau problems.

The Bureau has installed seven ERTS data collection platforms high in the rugged San Juan Mountains of southwestern Colorado as part of Project Skywater, a weather modification research program. Here, amid deep, wind-driven snow and bitter cold, the platforms have proven to be extremely reliable communication tools.

Weather information relayed rapidly by the DCS is incorporated in the cloud-seeding decisionmaking processes of the Colorado River Basin pilot project, the largest winter cloud-seeding research program in the Nation.

Sensing devices linked to the platforms monitor precipitation, temperature, relative humidity, ice riming, wind direction, wind speed, snow-water content, and streamflow. Data from each of the seven platforms are relayed to the satellite during each overhead orbit, then through Goddard Space Flight Center in Maryland to a time-share computer in Denver where the data are translated into measured units and stored on file for access by users of Skywater's Environmental Computer Network.

The seven platforms, in remote regions accessible only by snow vehicles or helicopters, are tested under severe conditions to determine their operational suitability, maintenance requirements, reliability, and cost effectiveness.

The seven platform sites reflect a variety of terrains, but all experience severe weather. One, near the crest of Wolf Creek Pass, Colo., is in an area which received 590 inches of snow during the 1972-73 winter. Winds in excess of 60 miles-per-hour are not uncommon, and temperatures plummet far below zero.

Although the system is still in a test mode, Bureau meteorologists have gained much data from it. During the spring of 1973, when spring snows raised the possibility of floods in the valleys below, Skywater sus-

pended the seeding project because of a decision based, in part, on timely information provided by the ERTS data collection system.

Data collected through remote sensing is currently being used in the Bureau to monitor the environment during construction and operation of a pumped-storage powerplant, to determine cold air drainage patterns in orchard areas, to aid in management of undesirable vegetation, to delineate areas of shallow ground water on agricultural lands, to conduct sediment surveys and land-use classification studies, and to monitor environmental impact.

Scientist checks a recording precipitation gage in the San Juan Mountains, Colo. Information is sent from the gage to ERTS–1.

Numerous additional opportunities exist for the application of remote sensing data in Bureau operations with the promise of more and better data which are more frequently and easily obtained. Plans are now in progress for the future use of remote sensing to assist in obtaining information for the following types of Bureau activities:

- Runoff forecasting based on satellite observations of mountain snowpack in drainage basins that supply water for Bureau projects.
- Periodic observation of sediment accumulations in reservoirs and evaluation of sediment-producing potential of drainage basins.
- Observation of present and developing seepage or drainage problem areas.
- Taking inventory of irrigated lands and cropping patterns to determine changes in area for improved water use.

Data collected is used in weather modification programs for augmenting water supplies. It could be used to gather crop census data on projects more accurately and economically. The potential also exists to determine plant vigor and associated yield estimates.

And it could provide timely and rapid acquisition of basic water resources data to achieve better conservation, management, and use of existing supplies.

Satellites, such as ERTS, are revolutionizing data collection, and the application of remote sensing in Bureau activities promises to become increasingly useful as the full range of its potential is explored and exploited.

Consider for a moment, that the resources now exist not only to photograph every single farm in the world but to tell what crop is being raised on that farm, whether the crop is young or old, healthy or diseased, and what the yield will be. It can decrease pollution, increase productivity, and save money for the farmer by telling him of impending disease or insect attack, many months in advance. And it can tell him exactly what section of his crop might be in danger. The farmer might be able to treat a specific 100 acres of cropland instead of pouring chemicals indiscriminately on 1,000 acres fearing they would all be threatened. In short, the technology exists to check that devastating killer of man in today's world: famine.

In the future many everyday Bureau tasks now done manually by field personnel may be performed automatically by electronic command signals. An example of improved irrigation efficiency might include turning on an irrigation valve when remote sensing indicates a field is becoming too dry and turning off the valve when, a few passes later, the satellite ascertains the field has been sufficiently watered. After a few more years of innovative development of remote sensing, a satellite of such capabilities may well become a reality.

Remote sensing is presently a new and valuable tool for resource management and, potentially, one of the most powerful tools in man's history for monitoring the Earth and its environment.

REMOTE SENSING

THE SIGNIFICANT ACCOMPLISHMENTS

The list of its achievements is almost too long to mention, however, a digest of some significant accomplishments using ERTS data includes:

Flood plain mapping—ERTS application established on East and West Nishnabotna River, Iowa; Gila and Salt Rivers, Ariz.; Mississippi River from St. Louis, Mo.; to the Gulf of Mexico. This work demonstrated that effects of flooding could be mapped after peak stage and that repetitive observations could track the flood crest at several locations. It also demonstrated that 35,000 square miles of the Mississippi Basin could be mapped for less than $20,000 to determine the extent of inundation, to assess regional effectiveness of flood control measures, and to identify areas where significant changes may be required to avoid disasters.

Snow cover mapping—ERTS images coupled with data collection platforms (DCP's) improved runoff forecasts of the Salt River Watershed in time to lower reservoirs, to increase power generation and to avoid floods in Phoenix.

Water quantity and quality—DCP's measuring quantity and quality of water have been relayed via ERTS from watersheds in Arizona, Pennsylvania, Delaware, Florida, and the New England States. Coupled with images, estimates can be made for improved water management.

Ground water—Analyzing images of linear features, many related to fracture systems, has provided new insight into the exploration for and development of ground water resources in Arizona, Pennsylvania, and Alabama.

Reservoirs and dams—Impoundments as small as four acres can be identified from ERTS images.

ERTS data is now being used by Corps of Engineers to locate water impoundments under the National Program for the Inspection of Dams.

Air—Smoke plumes from industrial centers and fossil fuel plants have been mapped in San Francisco, Chicago, the Four Corners Region, and in cities of Virginia.

Water—Paper plant waste effluent at Fort Ticonderoga, N.Y., mapped from ERTS image of Lake Champlain, is being used in a law suit by the State of Vermont. Turbidity patterns in Delaware Bay, as seen in ERTS, provide insight on tide dynamics and planning for deep-water ports. Turbidity pattern and algae concentrations are being monitored in San Francisco Bay. Oil slicks identified in ERTS images suggest capability for spotting and tracking pollution.

Land—Strip mine activities in Ohio have been mapped using ERTS. Ohio found an 18-percent increase in stripped land area, surveyed at a cost of less than $20,000. In 1960, a similar study using conventional techniques cost $200,000. The feasibility of monitoring western coal stripping activities has been established. Siltation from construction and floods in rivers, lakes, and reservoirs has been proven through use of ERTS data.

Agriculture, forestry, and range management crop classification—Accuracies of 80–90 percent have been recorded for: corn and soybeans in South Dakota, Illinois, and Michigan; field corn and popcorn in Nebraska; winter wheat in Kansas; and rice, safflower, asparagus, corn, and cotton in California.

Timber and grassland inventory—Using a color composite image of Seward Peninsula, Alaska, seven vegetation types were delineated in 10 man-hours of which only four had been described on existing maps.

The Bureau of Land Management is using ERTS data to monitor grassland growth in central California and parts of the Great Plains.

Land use—The analysis of how land use has changed has been demonstrated in Phoenix, Ariz. and this data is being used by State tax assessors.

Eleven categories of land use have been identified in ERTS data for Rhode Island and have been confirmed by high-altitude photography. As already noted, it is less expensive to use ERTS data than data obtained from conventional methods.

Joint Federal-State land use planning—The Commission of Alaska is using ERTS for land-use inventory to aid in the selection of 32,000 square miles of public domain for State, Indian, and public use.

Updating small-scale maps—ERTS images have corrected and improved maps at various scales. Mosaic maps of Nevada and California have been made from many images. Maps of Delaware, New Jersey, Florida, and Arizona are now in production.

ERTS has been used to identify the need to revise large scale maps.

Geological resources and analysis—ERTS image mosaics provide regional perspectives. These larger perspectives are called "synoptic views". They allow the mapping of major lineaments. For example, the 700-mile lineament across northern Nevada extending into California, Idaho, and Montana may be a major break along which volcanism, geothermal areas, and scattered ore deposits are located.

Volcano and earthquake monitoring—Ground sensors and ERTS data relay capability successfully demonstrated that increase in seismic events prior to eruption can be used in forecasting such eruptions as the February 17, 1973, eruption of Fuego Volcano, Guatemala.

WATER QUIZ

1. What is juvenile water?
2. A human being can survive approximately 10 weeks without food. But, without water, a person can expect to live only:
   a. 5 days
   b. 10 days
   c. 15 days
3. What part did water play in the invention of the 365–day calendar?
4. Which State has the most Reclamation recreation areas?
   a. California
   b. Colorado
   c. Texas
   d. Washington
5. In what State is the Annual World Championship Inner Tube Race and Colorado River Floatdown Parade held?

Photo courtesy *Yuma Daily Sun*

Answers on page 24.

In these days of crises and shortages, it is not too surprising to hear people talk about the possibilities of water shortages. But this is not new. Back in 1902, the need for the Bureau of Reclamation was realized because of the severe dearth of water in the West.

Today, as back then, the Bureau is striving to limit the bad effects of nature's failure to place water where man needs it. Water deliveries from Reclamation projects now total over 28 million acre-feet annually and service is provided to nearly 15 million people.

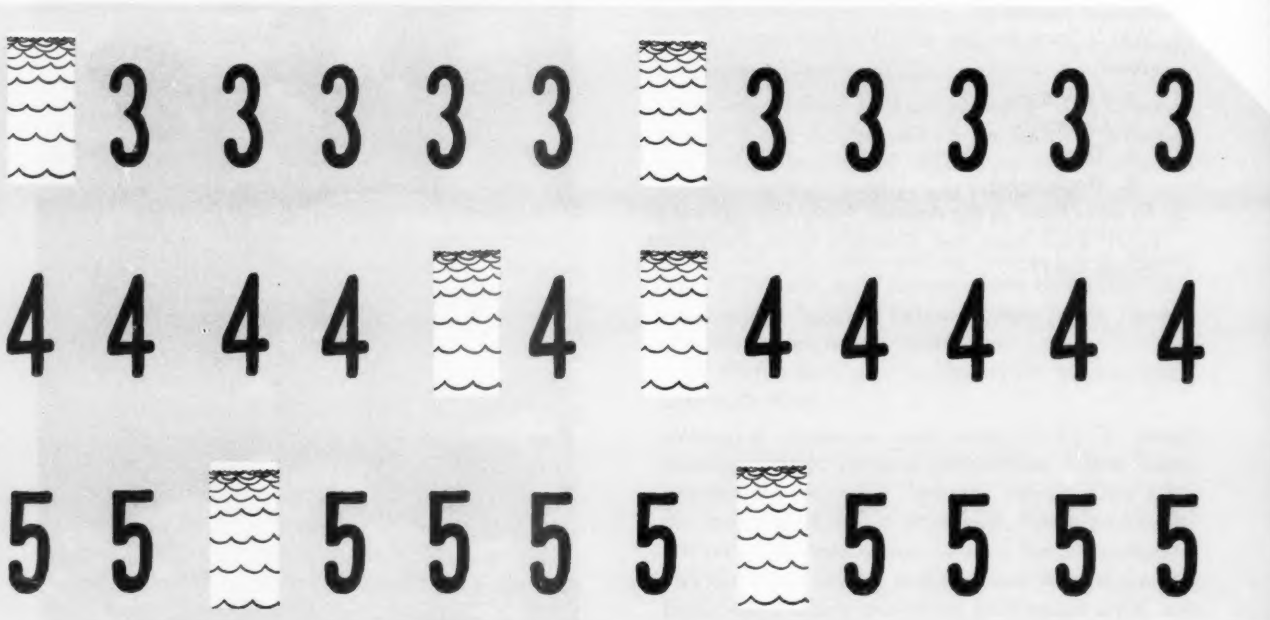
Deliveries are made to farms, municipalities, and industries. Canals, laterals, storage reservoirs, and diversion dams operate on Bureau of Reclamation projects to provide this service.

Considering these varied and extensive facilities and current and projected water needs, the best practical methods of water management must be developed and instituted to assure efficient use and conservation of existing developed water supplies.

Mismatches between diversions and deliveries can waste huge quantities of water. They can occur as a result of inaccurate regulation, unexpected changes in inflow or outflow, lack of adequate storage, and the long timelag inherent in conventional canal operation. For instance, many conventionally operated canal systems require a full day or more of travel time for

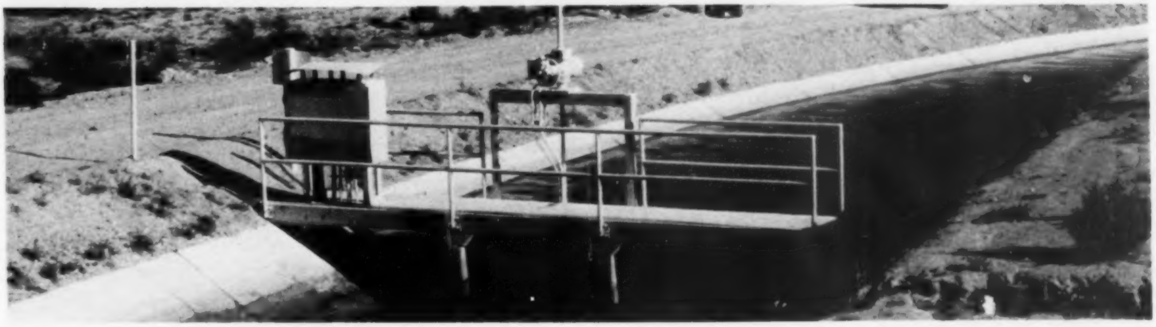
By the Water Systems Automation Team, E&R Center, Denver

AUTOMATED



WATER

An automated check point at the South Gila Canal, Ariz.



a change in flow to get through the conveyance system. The ability to accommodate increases or decreases in demand at the turnouts due to unexpected rainfall, critical temperature changes, or other reasons is dependent upon the timelag of the system.

Automation can greatly decrease the effect of this timelag, compensate for inaccurate regulation, and generally provide better service to the water users at less cost and with less waste of water. Control systems which make water more quickly available greatly enhance the margin of profit for water users, and those which accommodate quick shutoffs can improve system efficiency.

The water systems automation (WSA) team was formed at the Engineering and Research Center of the Bureau of Reclamation in 1971. The primary function of the WSA team is to coordinate within the E&R Center and with the regional offices all water systems automation and remote control activities requiring E&R Center attention relative to problems in research, planning, design, operation, and maintenance. In 1974 the team is managing a research and development program which will result in new automatic water control equipment.

Computers play a valuable dual role in water systems automation. Both the analysis of control problems and real time control are performed with computers. The analysis of control problems is often accomplished with a mathematical model or computer program which simulates the water system under study. Real time control, as the name implies, is control in the present time frame. As system changes occur, the controller immediately senses and makes appropriate adjustments.

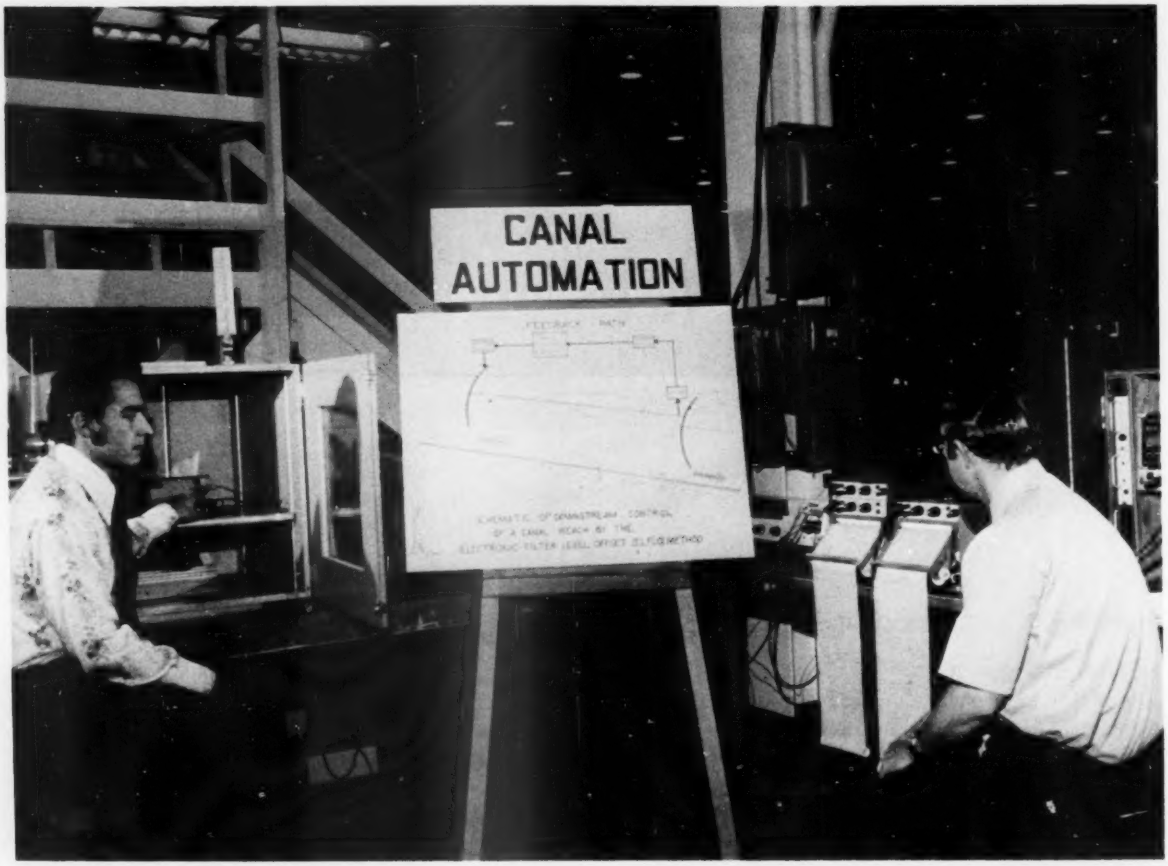
Mathematical models of hydraulic features are valuable tools for the researcher, the designer, and the operator. The results of applying a particular scheme of operation to a water system can be determined by writing a computer program to mathematically model the system and by imposing operational and control concepts on the model.

The ultimate mathematical model would combine the simulation of any water system under any scheme of operation with techniques of operations research to find the optimal scheme.

This ultimate model does not appear to be practical at the present time. However, mathematical models of open-channel systems can be versatile enough to accommodate a wide range of canal systems being studied under a variety of operating schemes.

Likewise, mathematical models of pressure pipe systems are usually designed not as unique models limited to one system but as models which can be used to study a wide range of systems and assumptions of operation. Thus, the response to a water system can be determined for any number of schemes.

Large water conveyance and distribution systems may be adapted to be controlled from a centralized computer system. Alternatives include the use of a combination of local automatic and centralized computer control systems. Initial studies indicate virtually any control method using onsite control components



Researchers at the E&R Center analyze canal automation.

The computer at the E&R Center used for water automation.

The Water Systems Automation Team on the model of the canal includes: (l to r) Joseph L. Johnson, Mechanical Branch; Rudy S. Hogg, Electrical Branch; Deso L. Winsett, Hydraulic Structures Branch; Charles A. Calhoun, Team Leader, Operations Branch; and Jack Schuster, Hydraulic Branch.

can be programed into a computer. The computer then provides an equivalent control of the structure but performs the control from a central location.

An important development parallel to water systems automation in the Bureau of Reclamation is the irrigation management services (IMS) program. Applying the proper amount of water to crops at the correct time is the goal of this effort. IMS provided information relative to the scheduling of irrigations on over 200,000 acres of irrigated land in 10 States during the 1973 irrigation season. In furnishing information on efficient use of water, irrigation scheduling provides benefits to the irrigator, the irrigation district, and to the Nation.

Many of the benefits are identical or similar to those for automation. To a certain extent irrigation scheduling is a form of automation and a joint development is required. A recent automation study concluded that computer requirements for programable master supervisory control are compatible with those required for irrigation scheduling.

Other developments underway in the Bureau which complement automation include the use of operations research/systems analysis techniques to optimize operations and mathematical modeling of entire river basin operations to obtain forecasts of quality and quantity.

Advances in technology now make automatic control feasible for almost any water system. Equipment is becoming available which can be used to monitor and control even the most complex installation. While application of these new tools of technology to water projects is limited by their costs, increased system efficiencies, better utilization of manpower, and more reliable control often can offset these costs.

news NOTES

Lewis and Copen Honored

Alfred T. Lewis and Merlin D. Copen received the Department of the Interior Distinguished Service Award at an Honor Awards Convocation, held last June 27.

Lewis, former Chief, Hydraulic Structures Branch at the E&R Center, retired June 29, 1973. His Federal career spanned 35 years, the last 33 years were with the Bureau of Reclamation. The citation on his award read, in part: ". . . an exceptional design engineer, an outstanding coordinator of designs . . . a strong leader in introducing innovative design concepts . . . a superb administrator of a large, diverse, highly capable design organization . . ."

Alfred T. Lewis, Commissioner Gilbert G. Stamm, Merlin D. Copen

Copen, former supervisory civil engineer at the E&R Center, retired June 30, 1973. Copen was a Federal career employee of more than 33 years, all spent with the Bureau with the exception of 7 months. The citation reads, in part: ". . . an outstanding engineer in the field of dam design and a world-recognized authority in the design and analysis of arch dams."

Anderson is Assistant Commissioner—Administration

Donald D. Anderson became Assistant Commissioner for Administration on June 19. He succeeds Wilbur Kane.

Anderson joined the Bureau of Reclamation in 1947 as a civil engineer on the Columbia Basin project. In 1958 he transferred to the Washington office in the Division of Program Coordination and Finance (PC&F). He was appointed Assistant Chief of PC&F in 1968 and a year later was named Chief of the division. For the past 17 months, Anderson had been serving as Acting Assistant Commissioner for Administration in addition to his duties as Chief, Division of Program Coordination and Finance.

Donald D. Anderson, Assistant Commissioner for Administration

James D. Ellingboe, Chief, Division of Planning

Ellingboe Heads Division of Planning

James D. Ellingboe is the new Chief of the Division of Planning. He succeeds James J. O'Brien who is now Assistant Commissioner for Resource Planning.

Ellingboe has been Special Projects Officer in the Planning Division since 1969, and in that role was actively engaged in the Colorado River water quality improvement program and in the final solution to the United States-Mexico salinity problem.

Before coming to Washington, D.C. in 1967, he was Chief of the Hydrology Division, at the Upper Columbia Development Office at Spokane.

Ellingboe has been with the Bureau since 1948, beginning as an engineer trainee for the Deschutes project in Bend, Oreg. He is a native of Two Rivers, Wis., and has a B.S. degree in mechanical engineering from the University of Minnesota and a B.S. degree in civil engineering from the University of Wisconsin.

Answers to Water Quiz

1. *Juvenile water is water that has been trapped deep within the Earth and has not been a part of the endless circulation cycle of water on the Earth's surface.*
2. *b. 10 days*
3. *The Egyptians invented the 365-day calendar, based on the flooding of the Nile River.*
4. *d. Washington (total of 35)*
5. *Arizona*

Back Cover: The mighty Colorado River's last drop of water in Mexico.

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